MANAGEMENT AND ENHANCEMENT OF THE STOCK OF *PENAEUS ORIENTALIS* KISHINOUYE IN THE YELLOW SEA AND THE BOHAI SEA

Penaeus orientalis is a large, temperate, migratory species occurring between latitudes 33°30'–41°00'N. It overwinters (December to March) in waters of 60–80 m depth in central and southern areas of the Yellow Sea, and spawns from early May to early June around estuaries of the Yellow Sea and the Bohai Sea. As the shrimp fishery is intensively exploited, recruitment is related to spawning stock, as well as factors such as rainfall, runoff and salinity.

The year class yields of the shrimp in the Bohai Sea have shown periodic fluctuation in recent years. The average yield was 26,580 t in the late 1950s 19,391 t in the 1960s, 30,430 t in the 1970s, 19,297 t in the early 1980s. The maximum yield of 50,653 t occurred in 1979 and a minimum yield of 6,429 t occurred in 1984. Although the average yield in the early 1980s was similar to the 1960s, since then the shortage of spawning stock has led to a decrease of year class recruitment.

The management of shrimp fishery in the Yellow Sea and the Bohai Sea involves two strategies.

1. The protection of spawning stock and postlarvae so as to increase year class recruitment. A regulation forbids their capture along the migration route and in the spawning grounds. In addition, there are regulations which protect postlarvae and juvenile shrimps in the Bohai Sea. This protection includes closed areas and closed periods for the use of nets that could damage postlarvae and juvenile shrimp, and prevention of damage to postlarvae and juvenile shrimp by pumping water for pond culture, salt-making and other industrial usage.

2. The management of the autumn fishery in the Bohai Sea, or the problem of how to utilise and allocate the resources after a year class has matured. Before 1987, the open dates of the autumn shrimp fishery in the Bohai Sea were September 5 for drift nets, September 15 for motor-sailboats equipped with trawls, and October 5 for motor-trawls. From the beginning of the 1988 autumn fishing season, all trawlers have been excluded from the Bohai Sea, and only ships equipped with shrimp drift nets, are permitted to fish in the autumn fishing season in the Bohai Sea.

The major problems of the autumn shrimp fishery involve the huge fishing power employed, high fuel use and poor economic efficiency. Beyond a certain level, fishing mortality (F) does not increase linearly with fishing power. This is due to the limited shrimp fishing areas in the Bohai Sea and over-concentration of fishing vessels. When the number of fishing vessels is beyond a certain limit, fuel consumption rises while fishing coefficient (q), production rate and profit decrease.

The numbers of all major types of nets used in the autumn shrimp fishery in the Bohai Sea and the shrimp catch differs greatly from year to year. From the 1960s to the early 1970s, shrimp catch was largely made by bottom trawls of motor-sailboats and motor-trawlers. In late 1970s, owing to an earlier opening date, the shrimp drift net fishery developed rapidly and shrimp yield from drift nests increased. By 1980s, they began to dominate shrimp fishery, capturing more than 80% of the yield from 1986 to 1987.

Shrimp Stock Enhancement

Shrimp recruitment fluctuated from year to year, ranging from 1.07×10^8 (1985) to 1.40×10^8 (1961). The shrimp resource has had a low recruitment level particularly since early 1980. Hence, the release of hatchery reared larvae can be expected to enhance the shrimp resources in the Bohai Sea and increase yields.

Postlarvae, 30–50mm in length, are regarded as the best size (ecologically and economically) to release. There are many shrimp hatcheries and farms along the coast of the Bohai Sea that are capable of providing seed for release. The waters around the estuaries of the Yellow River, Haihe River and other rivers in the Bohai Sea are ideal release areas with suitable conditions (good water quality with abundant food, and few predators) for shrimp survival.

The best release time is when the sea water is muddy after strong winds, on the ebb, and when water is not being pumped by power plants and salt works. Postlarvae are easily caught by predators immediately after being released as the larvae are weak and stressed by new environmental conditions. Proper selection of release time and sites is therefore of great importance to minimise natural and made-made mortality.

Determination of the optimal quantity of postlarvae for release in a specific sea waters is a complex problem. The optimal quantity depends on the ecological capacity and natural recruitment abundance in the specific waters. Artificial releases can considerably affect ecological balance, interspecific relations and population succession. By using an annual shrimp resources estimation model, the shrimp number required to maximise catch in the Yellow Sea and the Bohai Sea was estimated to be 1.2 billion (food is a major limiting factor to increase of shrimp recruitment).

Since 1984, commercial shrimp postlarvae releases have been carried out in the Bohai Sea, the Yellow Sea and the east China Sea. Good results have been obtained; recapture rate was estimated as *c.* 10%. In the East China Sea, where the original *P. orientalis* population was very small, a natural stock large enough for fishing has grown up after many years of releases. In the inshore waters of the Yellow Sea, where previously natural shrimp populations were small and annual recruitment showed large fluctuation, recruitment has steadily risen after a series of large-scale seed releases. There is still a great potential for artificial seeding the Bohai Sea. The release numbers will be increased in years to come to reach the ecological capacity of the region.

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